EVALUATION USE OF *BACILLUS MUCILAGINOSUS* AS BIOFERTILIZER INTERFERE WITH *GLOMUS MOSSEAE* ON GROWTH AND YIELD OF CORN

* A. S. Hussien **H. A. abdul- Ratha *H. A. Hadwan
Researcher Prof. Chief Scientific Researchers
*Ministry of Agriculture /Plant Protection Office
**Department of Desertification. College of Agriculture / University of Baghdad
hasan_a_abd@yahoo.com

ABSTRACT

The current study was aimed to isolate and diagnosis *Bacillus mucilaginosus* and evaluate its use as biofertilizer alone or interfere with *Glomus mosseae* on growth and yield of corn (*Zea mays* L.) Randomized completely block design was used at the Field of College of Agriculture-University of Baghdad Al-Jadriya in silt clay loam soil. The biofertilizer was used alone or as combination that added with or without 50 Kg P ha^{-1} of rock phosphate and with or without 120 Kg K ha^{-1} while, 250 Kg N ha^{-1} was added as urea (46%N) to all treatments. Results showed the superiority of bacterial or fungal biofertilizer on enhancing all growth traits of corn and the addition of *B . mucilaginosus* together with *Glomus mosseae* resulted superiority for plant height , dry weight of vegetative part , grain yield and biological yield with the values 229.4 cm , 180.7 gm .plant^{-1},12.17 tons ha^{-1} and 19.59 tons ha^{-1} respectively. As well as treatment gave significant increase equal the increase in the yield due to addition of completely recommended mineral fertilizer which was 12.14 tons ha^{-1} .

Key words: potassium dissolving bacteria ,mineral fertilizer , mycorrhiza

***Part of Ph.D Dissertation of 1 st author.**

تقييم أستعمال بكتريا *Bacillus mucilaginosus* كسماد حيوي بالتداخل مع فطر *Glomus mosseae* في نمو وحاصل الذرة الصفراء .

*أسماء سليم حسين **حسن علي عبد الرضا * حميد علي هدوان
باحث أستاذ رئيس باحثين
* دائرة وقاية المزروعات / وزارة الزراعة ** قسم مكافحة التصحر / كلية الزراعة – جامعة بغداد * دائرة وقاية المزروعات / وزارة الزراعة

المستخلص

هدفت الدراسة الحالية عزل وتشخيص بكتريا *Bacillus mucilaginosus* وتقييم تأثير أستعمالها كسماد حيوي بمفردها أو بالتداخل مع فطر *Glomus mosseae* في نمو وحاصل الذرة الصفراء. أستعمل تصميم القطاعات تامة التعشية في تنفيذ التجربة الحقلية في أحد حقول كلية الزراعة – جامعة بغداد / الجادرية في تربة مزيجية طينية غرينية وأستعمل السماد الحيوي بصورة منفردةً أو كتوليفة سمادية وذلك بالتداخل مع إضافة 50 كغم P .هكتار$^{-1}$ من صخر الفوسفات أو عدم أضافته و120 كغم K .هكتار$^{-1}$ من كبريتات البوتاسيوم أو عدم أضافته ، في حين تمت أضافة التوصية السمادية الكاملة 250 كغم N .هكتار$^{-1}$ بأستعمال سماد اليوريا (46%N) وللمعاملات جميعها . بينت نتائج التجربة تفوق اللقاح البكتيري أو الفطري في جميع صفات نمو الذرة الصفراء كما تفوق أضافة بكتريا *B.mucilaginosus* + فطر *Glomus mosseae* معاً على اللقاح البكتيري أو الفطري في ارتفاع النبات والوزن الجاف للمجموع الخضري والحاصل البايولوجي وحاصل الحبوب،اذ سجلت معاملة التداخل تلك 229.4 سم و 180.7غم نبات$^{-1}$ و 19.59 طن هكتار$^{-1}$ و12.17طن هكتار$^{-1}$ في الصفات المذكورة بالتتابع كما حققت معاملة التداخل زيادة معنوية تكافئ الزيادة عند اضافة التوصية السمادية الكاملة في صفة حاصل الحبوب ،إذ بلغت 12.14 طن هكتار$^{-1}$.

الكلمات المفتاحية : البكتريا المذيبة للبوتاسيوم، الاسمدة المعدنية ، مايكورايزا .

***جزء من آطروحة دكتوراه للباحث الاول.**

*Received:29/6/2018, Accepted:9/9/2018

INTRODUCTION

The optimum use of soil microorganisms activities are an important step to increase the available of nutrients for plant and hence develop the agriculture, Biofertilization is a technique which are alternative, inexpensive and appropriate source for environment in comparison with chemical fertilizers (30) . Researchers were carried out many attempts to isolate and diagnosis different microorganisms and use its as agent of biofertilizers. There are different microorganisms which have an important role in the geochemical cycle of different nutrients like nitrogen, phosphorus and potassium and some rhizosphere bacteria have the ability to dissolve potassium easily from soil and potassium carrying minerals such as mica ,illite and orthoclase by producing different rock and silicon chelating ions to produce dissolved potassium in soil solution (5) . It was found that potassium dissolving bacteria *Bacillus mucilaginosus* produce numbers of enzymes such as nuclease, endoglucanas ,cellobiase ,protease ,ribonuclase and phosphomonoestrase which some of its do important role in potassium release mechanism (51). Phosphorus is an important nutrient for plant development and cell division (42). Some studies indicated the important role of micorrhiza fungi in improving water relations and increase plant resistant to drought (41), *Glomus mossase* is one of the most important and most dispersal in soil (55). The current study was aim isolation and identification of *B.mucilaginosus* and use it as biofertilitzer alone or with *Glomus mosseae* to evaluate its effect on growth and yield of corn.

MATERIALS AND METHODS

This study was carried out at the field of the Research Station -College of Agriculture University of Baghdad during2016-2017 in silt clay loam soil with chemical ,physical and biological characteristics (14,15,16,23,25,37,39,54) (Table 1), to study the effects of *Bacillus mucilaginosus* as biofertilizer alone or with *Glomus mosseae* on growth and grain yield of corn (*Zea mays* L.). Selected *B.mucilaginosus* was isolated because of its high efficiency in dissolving potassium and grown on Aleksandrov broth medium at 28C̊ for 3 days .The infected roots and soil with spores of *Glomus mosseae* inoculum was added at depth 5 cm in the holes while *Bacillus mucilaginosus* was added to the peat moss as carrier by mixing 100 ml of

Table1. Some physical , chemical and biological characteristics of soil before planting

	Properties	Unit	Value
	pH		7.2
	EC_e	dS m^{-1}	1.3
	NH^+_4		49
	NO^-_3	mg kg^{-1}	42
	P		3.0
	K		179
Dissolved ions	Ca^{++}	mmeq L^{-1}	9.68
	Na^+		10.44
	Mg^{++}		6.32
	SO_4^{-2}		7.28
	Cl^-		11.22
	HCO_3^-		2.92
	CEC	Cmol kg^{-1}	15.3
	Organic matter	gm kg^{-1} soil	6.8
Soil separators	Sand		182.16
	Silt	gm kg^{-1} soil	469.74
	Clay		348.10
	Class texture	Silt Clay Loam	
Number of microorganism	Number of Total bacteria	CFU gm^{-1}dry soil	$1.5*10^9$
	Number of Total fungi		$1.8*10^4$

bacterial inoculum with 150 g of peat moss and 50g of charcoal powder. The soil was prepared after plowing by the rotary plow ,leveling . The Field was divided into three block leaving guard spaces among them. At 22/3/2017 three corn seeds (Baghdad 3 cultivar) were planted in hole and the distance between hole and other was 40 cm and after emergence one seedling was conservative at each hole. The field experiment consist from three factors , the first was biofertilizer with four types(with out inoculation , *Bacillus mucilaginosus* inoculum ,*Glomus mosseae* inoculum ,mixture of *B.mucilaginosus* + *Glomus mosseae*), the second factor include with and with out potassium sulphate addition while the third factor include with and with out rock phosphate addition ,A RCBD with three replicates was used in this experiment ,each block consist of 16 experimental units with $9m^2$ area (the total of experimental units were 48), and each experimental unit consist of three lines ,the distance between each row was 75cm. mineral fertilizers were added according to the recommendation for nitrogen fertilizer to all treatments, using urea (46%N) 250 Kg N ha^{-1} In two doses ,the first at planting and the second after 45 days of emergence ,while 120 Kg K ha^{-1} potassium sulphate (42%K) was added and 50 Kg P ha^{-1} of rock phosphate (10%P) for one dose at planting according to the treatments .The soil moisture was up to 50% of available water and the loses of water added during record the depth and volume of irrigated water using sensors which were put at different depth (10,15,30 and 45)cm and joined with data logger. 22/7/2017 at the end stage of experiment ,plant height , dry matter of vegetable part , Biological yield and grain yield were recorded .

RESULTS AND DISCUSSION

Plant height(cm)

Results of the field experiment in Table 2 shows superiority of all biofertilizers treatments(bacterial and fungus) in plant height over the control (No biofertilizer). The *B. mucilaginosus* bacterial inoculant treatment had an average plant height of 216.6 cm, while the control treatment had 214.8 cm ,but this increase did not significant . The *Gloums mosseae* fungus treatment gave an average plant height of 224.1 cm, which was significantly higher than the control treatment by 4.33% . This can be attributed to the ability of mycorrhizal fungus to absorb nitrogen, phosphorus,potassium, calcium, sulfur, iron, magnesium , cobalt and zinc from the soil to the plant by roots as it ,has been indicated by other researchers (35,55) Beside that potassium effect of mycorrhizal fungus in improving photosynthesis process and enhancing absorption of some nutrient especially phosphorus(1) and encouraging water and nutrient absorption (41) which enhanced plant height .Bashier (13) obtained similar results for wheat and Hamdan (26) for corn crop when using *G.mosseae* fungus . The combined (bacteria and fungus) treatment gave plant height (229.4 cm) significantly higher than the control by 6.8%. This can be related to the synergic role of both bio fertilizers (bacteria and fungus) in making nutrients available for plants especially macronutrients NPK also, production of some growth regulators such as gibberellin , oxen, cytokine . which stimulate plant cells to division and hence more plant height (57). The rock phosphate and potassium sulfate treatments gave significant difference in plant height, which had averages of 225.6 cm and 224.7 cm with increase of 4.06 % , 3.22% in comparison with no rock phosphate and no potassium sulfate treatments which had plant heights of 216.8 cm and 217.7 cm ,respectively . The treatment of bacterial inoculant and rock phosphate gave significant increase in plant height (224.5 cm) over the control treatment 208.0 cm with an increase of 7.93% . This may be due to ability of bacteria to release some organic acids such as malic acid and formic acid which dissolve the phosphate and this was reflected possibly on plant height (32).The treatment of bacteria inoculant with potassium sulfate has increased plant height as 220.2 cm over the control but this increase did not significant. From the other side, treatment of fungal inoculant and rock phosphate produced significantly highest plant height, fungus inoculant which was 225.3 cm with an increase of 8.32% .This was attributed by researches to the fact that the presence of mycrorrizha fungus in root zone may increase plant ability to absorb phosphorous in case it is available in sufficient quantities and hence the result is good plant height (24). Treatment fungus inoculant and potassium sulfate were nonsignificant increase in plant height (226.0 cm). Treatments triple interaction (bacteria and fungus inoculant with rock phosphate), (bacteria and fungus inoculant with potassium sulfate), (bacteria inoculant with rock phosphate and potassium sulfate), (fungus inoculant with rock phosphate and potassium sulfate),(bacteria and fungus inoculant with rock phosphate and potassium sulfate), gave increase in plant height as 229.4,228.3, 227.4,228.2,233.2 cm , respectively, but all increases non significant.

Table 2. Effect of different factors on the height (cm) of corn

Biofertilizer treatments	Rock phosphate	Potassium		biofertilizer x Rock phosphate
		Without K_2SO_4	With K_2SO_4	
control	Without rock	195.3	220.7	208.0
	With Rock	219.8	223.2	221.5
Bacillus.mucilaginosus	Without rock	204.5	213.0	208.7
	With Rock	221.5	227.4	224.5
Glomus.mosseae	Without rock	221.9	223.8	222.9
	With Rock	222.4	228.2	225.3
Bacillus.mucilaginosus +Glomus.mosseae	Without rock	226.8	228.3	227.6
	With Rock	229.4	233.2	231.3
LSD		N.S		7.5
Potassium sulfate average		217.7	224.7	
LSD		3.8		
Inoculant treatments * potassium sulfate				
		Without K_2SO_4	With K_2SO_4	Inoculant average
Without inoculant		207.6	222.0	214.8
Bacillus.mucilaginosus		213.0	220.2	216.6
Glomus.mosseae		222.2	226.0	224.1
Bacillus mucilaginosus +*Glomus.mosseae*		228.1	230.8	229.4
LSD		N.S		5.33
Rock phosphate *potassium sulfate				
		Without K_2SO_4	With K_2SO_4	Rock phosphate average
Without rock phosphate		212.1	221.5	216.8
With rock phosphate		223.3	228.0	225.6
LSD		N.S		3.8

Vegetative dry weight (gm plant $^{-1}$)

Results in Table 3 shows that all biofertilizer treatments produced significantly highest vegetative dry weight over control treatments. Addition of *B.mucilaginosus* bacteria resulted significantly increases in vegetative dry weight as 172.41 gm plant $^{-1}$ with increases of 5.67% gm plant $^{-1}$ compared with the control (no bacterial inoculation) (163.16 gm plant $^{-1}$) in this respect (20) delected that when barley grains were inoculated with six isolates of bacillus caused an increase in plant growth and its vegetative part and root system growth due to the influence of bacteria, and this study was in accordance with study of other researchers (53) Al-Khalel (6) was found that the addition of plant growth simulated *B.muclaginosus* resulted in significant increases in dry weight of vegetative dry weigh and roots in comparison with control treatment. Addition of *G.mosseae* resulted in increase a vegetative dry weight of corn to 173.26 gm plant $^{-1}$ which was significant higher than the control treatment 163.16 gm plant $^{-1}$ with a percent increase of 6.19%. Inoculation with *G.mosseae* helped in producing more growth regulators such as IAA and water and nutrients absorption which have reflected positively on corn growth and in hence the increase in vegetative dry weight hence (49). (31) Mahmoud and Rizi (32) found in their studies using mycorrizha inoculation increased the vegetative dry weight Also, other researchers (2, 13,19,26,38) were reported that applying fungus bioinoculant caused increases in vegetative dry weight. Results showed that inoculation with both *B.mucilaginosus* and *G.mosseae* resulted in an increase in vegetative dry weight which is equivalent to application of both rock phosphate and potassium sulfate alone as rock phosphate treatment gave significant. increases in dry matter weight with value 176.70 gm plant $^{-1}$ with increases 5.14% in comparison with control of 168.06 gm plant $^{-1}$. while treatment of potassium sulfate gave significant increases in dry weight of vegetative part 176.71 gm plant $^{-1}$ with increase was 5.15% in comparison with control of 168.06 gm plant $^{-1}$.while the treatment of both bio fertilizers (bacteria and fungus) gave highly significant superiority dry weight 180.70 gm plant $^{-1}$ with a increase of 10.75% in comparison with control treatment which was 163.16 gm plant $^{-1}$ .This results confirm the importance of this microorganism in increasing the availability of phosphors and potassium in soil. The treatment bacteria and rock phosphate gave dry matter weight of 176.19 gm plant $^{-1}$ and this was significantly higher than the control which was 153.81 gm plant $^{-1}$ with increase 14.55%. While the treatment ,bacterial and potassium sulfate gave significantly for dry matter weight 176.51 gm plant $^{-1}$ than the control 154.99 gm plant $^{-1}$ with increases 13.88%.The treatment fungus with rock phosphate gave significantly increases 174.39 gm plant $^{-1}$ with increase 13.38%, the treatment of fungus with potassium sulfate gave significantly in dry matter weight of 175.49 gm plant $^{-1}$ than the control 154.99 gm plant $^{-1}$ with 13.23% increase . these results may due to for this is that the role of mycorrizha that may increase the production of phosphatase enzyme which increase phosphorus availability (11). Mycorrizha can Improve the activity of phosphatase enzyme inside the vesicular and internal hypha (21). This may be related to the interaction between the chemical and bio fertilizers which influence plant physiological processes throughout increasing photosynthesis components which at the end increase plant dry weight as a result of nutrients absorption from soil (47). The treatment of rock phosphate and potassium sulfate resulted in significantly increases in dry matter weight 178.68 gm plant $^{-1}$ than the control treatment 161.38 gm plant $^{-1}$ with of increases 10.72%. this can be attributed to the fact that the increases in plant ion nitrogen absorption play important role in the formation of amino acids which that are important for plant tissues which means more vegetative plant parts and higher dry weight because of good rooting system caused by phosphors though more water and nutrient absorption . Also because of the role of potassium in cell division and plant growth (34) as well as its role in enhancing nitrogen absorption and hence improving plant growth (52) and the role of potassium in the activity of numbers of enzymes especially those related to photosynthesis processes(18).Results showed that addition of bacteria and fungi inoculant with rock phosphate gave a significant increase in dry matter weight which 183.01 gm plant $^{-1}$,the increase was 32.34% in comparison with control treatment which was 138.29 gm plant $^{-1}$ .while the treatment of bacteria and fungi inoculants with potassium sulfate resulted in a significant increases in dry matter weight which was 182.66 gm plant $^{-1}$ with increases 32.08% the treatment of fungal inoculant with potassium sulfate and rock phosphate resulted in a significant increase in dry matter weight which was 176.35 gm plant $^{-1}$ with increases 27.52% compared to control treatment . The treatment of bacteria and fungi with potassium sulfate and rock phosphate significantly increases in dry weight. Which was180.65 gm plant $^{-1}$ with increase 30.63% in compare to control treatment. while treatment of bacteria and fungi with rock phosphate and potassium produced significant increases in comparison with most of the doable and control treatment ,the dry weight was 184.41 gm with of increases 33.35% , these increasing may due to the activity of the added microorganism by different mechanism such as dissolving the unavailable material and releasing nutrients in soil and secrete some hormones and growth regulator which helps cell division and improving plant growth (17,50). Also adding mineral fertilizers increase nutrient availability which enhanced plant roots to absorb nutrient resulted in high dry weight (28). these results came in agreement with what was reported by Al-Khalel and Ali (6) as she indicated obtaining more dry weight as a result of adding both chemical and bio fertilizers.

Grain Yield (tons ha^{-1})

Results in Table 4 shows a significant increases in grain yield due to inoculation with both *B.mucliganosus* and *G.mosseae* fungi inoculant treatments which was 11.61 and 11.75 tons ha^{-1} with of increases 6.22% and 7.50% respectively in comparison with the control treatment which was 10.93 tons ha^{-1}. This may be due to the fact that the bacteria inoculation helps in to making potassium and phosphate more available in soil by producing organic acids and enhancing more nutrients absorption and hence more plant growth (36) . In this respect (60) emphasized that the presence of useful effects of potassium dissolving bacteria on sorghum resulted in more biomass and increase potassium and phosphate contents in plant which was reflected on grain yield compared with control treatment .Also other

Table3. Effect of different factors on the vegetable dry weight (gm plant^{-1}) of corn.

Biofertilizer treatments	Rock Phosphate	Potassium: Without K_2SO_4	Potassium: with K_2SO_4	Biofertilizer x Rock Phosphate
Control	Without rock phosphate	138.29	169.32	153.81
	With rock phosphate	171.69	173.33	172.51
Bcaillus mucilaginosus	Without rock phosphate	164.91	172.37	168.64
	With rock phosphate	171.74	180.65	176.19
Glomus mosseae	Without rock phosphate	169.61	174.64	172.13
	With rock phosphate	172.43	176.35	174.39
Bcaillus mucilaginosus +Glomus mosseae	Without rock phosphate	172.72	182.66	177.69
	With rock phosphate	183.01	184.41	183.71
LSD		8.34		5.90
Potassium sulfate average		168.05	176.71	
LSD		2.95		
Inoculant treatments *potassium sulfate		without K_2SO_4	With K_2SO_4	Inoculant average
Without inoculant		154.99	171.32	163.16
Bcaillus mucilaginosus		168.32	176.51	172.41
Glomus mosseae		171.02	175.49	173.26
Bcaillus mucilaginosus+ Glomus mosseae		177.86	183.53	180.7
LSD		5.90		4.17
Rock phosphate * potassium sulfate		Without K_2SO_4	with K_2SO_4	Rock phosphate average
Without Rock phosphate		161.38	174.75	168.06
With Rock phosphate		174.71	178.68	176.7
LSD		4.17		2.95

researchers (12) mentioned that inoculation with potassium dissolving bacteria resulted in an increase in grain yield of corn in comparison with control treatment since grain yield is a final result of all growth and development of plant (46). suitable potassium nutrient enhances nitrogen compounds translocation in grain crops and its simulation by cells, in addition potassium enhance biological processes including its potassium relation in increasing photosynthesis and movement of their products in case of good potassium absorption by increasing the synthesis ATP which increases phosphorous of photophos- phorylation(22).Some researchers (45) emphasized that the potassium dissolving bacteria not only improve soil fertility but also increase grain yield and decrease the need for chemical fertilizers. Addition of mycorrihza fungus increased nutrient absorption and gave a significant increases in grain yield , which was 11.98% tons ha^{-1} with increases 6.49% over control treatment 11.25 tons ha^{-1}. The increases in potassium availability in soil solution increases the ability of soil to support plants with this element and hence increase of efficiency of the photosynthesis process and increase its products (56) .In this respect other researchers (3,28) mentioned that potassium has direct influence on controlling plant Hormones which has relation with flower formation ,its inoculation and fruitfulness . this result came in agreement which results obtained by some researchers (7,9) which is the same significant for rock phosphate addition . The treatment of bacteria and fungus gave significant difference for grain yield with average 12.17 ton ha^{-1} (11.34%) increasing over the control treatment. And this may due to the addition of biofertilizers which encouraging the in plant growth throughout producing different materials like vitamins, IAA and gibberellin which helps in seed germination and increase grain yield, the growth of shoots and roots which resulted in increase grain yields(59). Other researchers (43) related this to potassium absorption which influence chlorophyll formation that helps in forming new cells (58) . A significant increase happened with the combine inoculation of (bacteria and fungus) which was 12.17 tons ha^{-1} in comparison with the control (No biofertilizers) which was 10.93 tons ha^{-1} and this was almost close to increasing caused by rock phosphate and potassium sulfate treatment which

Table4. Effect of different factors on the grain yield (ton ha^{-1}) of corn

Biofertilizer treatments	Rock phosphate	Potassium: Without K_2SO_4	Potassium: With K_2SO_4	biofertilizer *rock phosphate
control	Without rock phosphate	8.97	11.34	10.16
	With rock phosphate	11.46	11.93	11. 70
Bacillus mucilagionsus	Without rock phosphate	10.89	11.79	11.34
	With rock phosphate	11.85	11.91	11.88
Glomus mosseae	Without rock phosphate	11.14	11.89	11.51
	With rock phosphate	11.82	12.17	11.99
Bacillus mucilagionsus *Glomus+mosseae*	Without rock phosphate	11.73	12.25	11.99
	With rock phosphate	12.14	12.56	12.35
LSD		N.S		0.60
Potassium sulfate average		11.25	11.98	
LSD		0.30		
Inoculant * potassium sulfate treatments				
		Without K_2SO_4	With K_2SO_4	Inoculant average
Without inoculant		10.22	11.64	10.93
Bacillus mucilagionsus		11.37	11.85	11.61
Glomus mosseae		11.48	12.03	11.75
Bacillus mucilagionsus+ Glomus mosseae		11.94	12.40	12.17
LSD		N.S		0.42
Rock phosphate *potassium sulfate				
		Without K_2SO_4	With K_2SO_4	Rock phosphate average
Without rock phosphate		10.68	11.82	11.25
With rock phosphate		11.82	12.14	11.98
LSD		0.42		0.30

was 12.14 tons ha^{-1} in compared with the control treatment which was 10.68 tons ha^{-1} . Treatment of bacteria biofertilizer with rock phosphate gave significantly for grain yield which was 11.88 tons ha^{-1} with 16.93% increase high than control 10.16 tons ha^{-1}. Adding fungal inoculant with rock phosphate gave grain yield of 11.99 tons $ha^{-1}$with 18.01% increasing over the control .this can be attributed to the increase in available phosphorous soil which have importance role in metabolism processes and formation of energy compounds in addition to its impact on flowering and grain formation (33). Treatment of tri combination between bacteria inoculation with rock phosphate and potassium sulfate produced high grain yield of 11.91 tons ha^{-1} compare with control treatment .while treatment of bacteria and fungi treatment with rock phosphate gave higher grain 12.14 tons ha^{-1} as well as treatment of bacteria and fungi with potassium sulfate gave 12.25 ton ha^{-1} . and treatment of fungi with rock phosphate and potassium sulfate gave 12.17 tons ha^{-1}. While treatment of bacteria and fungi with rock phosphate and potassium sulfate produced 12.56 tons ha^{-1} . which were all greater than the control treatment (no addition) which was 8.97 tons ha^{-1} but the increase in triple treatment were not significant over the doable treatment

Biological yield (ton ha^{-1})

Results in Table 5 shows that there is a significant increases in the biological yield of corn inoculated with *B.mucilaginosus* or *G.mosseae* with a value 16.98 and 18.26 ton ha^{-1} ,respectively over the control treatment which was 15.35 ton ha^{-1} with10.62% and 18.96% increases over the control treatment ,respectively . the reason can be attributed to the fact that mycorrihza fungus increase the addition of bacterial inoculant with potassium sulfate gave an increase in grain yield which was 11.85 tons ha^{-1} in comparison to control (No bacteria and potassium sulfate) which was 10.22 tons ha^{-1} on the other hand treatment of fungal inoculant with potassium sulfate gave 12.03 tons ha^{-1} grain yield but was not significantly higher than control . amount of growth regulators released in growth medium like oxen ,gibberellin , cytokine which enhance the root hairs to grow and hence more plant growth and biological yield (26,40,44,57). Treatments of potassium sulfate and rock phosphate produced high biological yield than the control treatment which were 18.69 and 18.38 ton ha^{-1} with a significant increases as 13.96 and 9.99% over the control treatments (No addition) which were 16.40 and 16.71 ton ha^{-1} respectively. This may due to potassium role in enhancing cell division and increasing cells swelling and also increasing the efficiency of photosynthesis and its translocation to the other parts of plant also its role in enhancing numerous biological processes inside plant tissues which increases biological yield (10). Nutrients concentration in soil and hence more absorbed by plant which positively reflected on cell division and plant growth (3).this also resulted in more biological yield . Addition of chemical fertilizers (NPK) increases the nutrient availability which increases plant growth especially leaf area and hence simulating nutrients which increases plant growth and biological yield (4) bacteria and fungus treatment has increased the biological yield up to 19.59 tons ha^{-1} with 27.62% increases in comparison with control which was 15.35 tons ha^{-1} .This may be related to the potassium effect for both microorganism in increasing the biological nitrogen fixation for other microorganisms in soil throughout the increases in the ability of fungus to supply bacteria with phosphorous and other nutrient required as energy sources in addition to its positive effects on supplying plants with growth regulators which have their role in improving plant growth and productivity by enhancing plant rooting system to absorb nutrient and hence increase biological yield (48). This can be attributed to the fact that the biofertilizers increase total root system for plants by supplying plant with materials ,enzymes and vitamins such as B_{12} and some antibiotics that kill the harmful microbes in soil and hence increasing root efficiency to absorb micronutrient in soil (8). This result came in agreement with what was found by other researchers (29) .when they used mixed inoculant of *G.mosseae* mycorrhiza and *A.chroococcium* bacteria and bacillus sp. To study its effect on growth production and nutrient absorption of wheat crop in India.

They found that mycorrihza increased dry weight of shoots ,roots ,biological yield ,grain yield and straw .Also some researchers (26,53) emphasized inoculant of corn grains with biofertilizer increased crop growth and grain yield which increased biological yield .On the other hand addition of bacteria with rock phosphate has increase the yield biological to 17.82 ton ha^{-1},while adding fungus to rock phosphate yield 18.81 tons ha^{-1} in comparison with control yield which was gave 14.68 ton ha^{-1}

Table5. Effect of different factors on the biological yield (ton ha^{-1}) of corn

Biofertilizer treatments	Rock phosphate	Potassium		biofertilizer * rock phosphate
		Without K_2SO_4	With K_2SO_4	
Control	Without rock phosphate	13.19	16.18	14.68
	With rock phosphate	14.96	17.07	16.02
Bacillus mucilaginosus	Without rock phosphate	14.56	17.74	16.15
	With rock phosphate	17.39	18.25	17.82
Glomus mosseae	Without rock phosphate	16.33	19.08	17.71
	With rock phosphate	16.83	20.78	18.81
Bacillus mucilaginosus+ Glomus mosseae	Without rock phosphate	18.23	18.37	18.30
	With rock phosphate	19.69	22.07	20.88
LSD		N.S		N.S
Potassium sulfate average		16.40	18.69	
LSD		0.79		
		Inoculant * Potassium sulfate treatments		
		Without K_2SO_4	With K_2SO_4	Inoculant average
Without inoculant		14.08	16.63	15.35
Bacillus mucilaginosus		15.98	17.99	16.98
Glomus mosseae		16.58	19.93	18.26
Bacillus mucilaginosus +Glomus mosseae		18.96	20.22	19.59
LSD		N.S		1.113
		Rock phosphate * Potassium sulfate		
		Without K_2SO_4	With K_2SO_4	Rock phosphate average
Without rock phosphate		15.58	17.84	16.71
Rock phosphate		17.22	19.54	18.38
LSD		N.S		0.787

in comparison to treatment of bacteria with potassium the yield was 17.99 ton ha^{-1} ,while fungus with potassium sulfate treatment gave 19.93 ton ha^{-1} and the control was 16.63 ton ha^{-1}. Treatment of potassium sulfate with rock phosphate gave biological yield of 19.54 tons ha^{-1} , but this increase was not significant, while treatments of single bacteria or fungus and inoculant with both with either rock phosphate or potassium sulfate gave increase in biological yield of 19.69,16.33 ,18.25 ,20.78 and 22.07 ton ha^{-1} ,respectively in comparison with the control treatment (no addition) which was 13.19 ton ha^{-1} , but these increases did not significant .

REFERENCES

1. Abbot,L.K. and A.D. Robson. 1977. Growth stimulation subterranean clover with VA-mycorrhizas. Aust. J. Agric. Res. 28 : 639-649

2. Abd El-Ghany,Bouthaina. F.; A. M. Arafa, Rawhia.; Tomader,El - Rahmany and El-Shazly. 2010 . Effect of some soil microorganisms on soil properties and wheat production under north, Sinai,conditions. Journal, Applied Sciences Research.4 (5):559-579

3. Abu-Diahi,Y.M and M.A. Al-younis .1988. Directory of Plant Nutrition .University of Baghdad . Ministry of Higher Education and Scientific Research pp: 411

4. Ahmed, M.S. and J.S. Butt .1999. Effect of N.P.K. on some yield components of tomato *(Lycopersicon esculentum mill)*. J. of AARI. Anadola: 9(1): 56-62.

5. Aleksandrov, V.G.; R.N. Blagodyr and I.P. Iiiev .1967. Liberation of phosphoric acid from apatite by silicate bacteria. Mikrobiyol. Zh. (Kiev) 29: 111-114

6. Al-Khalel,S.M. and N.S. Ali. 2011. Effect of integrated mineral ,organic and biological fertilization on tomato*(Lycopersicon esculentum mill*) production and its nitrate content .Journal of Soil Science . (9) 1: (167-175

7. Asgharipour,M.R. and M. Heidari. 2011. Effect of potassium supply on drought resistance in sorghum: plant growth and macronutrient content. Pak. J. Agric. Sci. 48(3):197-204.

8. Al- Saidi,M.H. 2005. Plant breeding Under Different Stress Conditions Scare Resources and Physiological Bases. Publication of the Universities, Tanta University.Egypt

9. Al-Subiahi ,N.A.M. 2014. Effect of underage irrigation and levels of potassium fertilizers in the growth and yield of white maize (*Sorghum bicolor* L.) Moench .Ph.D. Dissertation Department of Field Crops. College of Agriculture .University of Baghdad.

10. Akram,A.M. S.Fatima; G.Ali, Jilani and R. Asghar. 2007. Growth yield and nutrients uptake of sorghum in response to integrated phosphorus and potassium management .Pak.J.Bot.39(4):1083-1087

11. Ayoob, M., I. Aziz and P. K. Jite. 2011. Interaction effects of arbuscular mycorrhizal fungi and different phosphate levels on growth performance of *Catharanthus roseus. Linn. Not. Sci. Biol*., 3(3): 75-79.

12. Basavesha K. N.; V. P. Savalgi,; M.N. Sreenivasa and H. Manjunatha .2016. Impact of bacteria solubilizing both potassium and phosphorus on growth and yield of maize (*Zea mays L.)* Res. Environ. Life Sci. 9(4) 464-465

13. Bashier, A. Y . 2003. Interaction Between Mycorrhiza and Azotobacter , Azospirillum Bacteria and its Effect on Growth and Yield of Wheat. Ph.D.Dissertation College of Agriculture-University of Baghdad.pp:168.

14. Black,C.A. 1965a. Methodes of soil analysis. Part 1. Physical and Mineralogical properties. Am. Soc. Agron. Inc. Madison. Wisconsin. USA.pp:1572

15. Black, C.A. 1965b . Methods of Soil Analysis, Part 2. Chemical and Microbiological properties, Am. Soc. Agron. Inc. Madison , Wisconsin, USA.Chemical pp:545-566 ; Microbiological pp: 1460-1466.

16. Bremner,J.M. D.R.Keeney . 1965 . Steam distillation methods for determination of ammonium , nitrate and nitrite. Anal. Chim. Acta, 32:485-495.

17. Bottini, R.; F. Cassan and P. Piccoli. 2004. Gibberellin production by bacteria and its involvement in plant growth promotion and yield increase. Applied Microbiology and Biotechnology, 65 : 497-503

18. Cakmak,I. 2005. The role of potassium in alleviating detrimental effects in plants. J. Plant Nutr.,168: 521-530

19. Dekkers, T.B.M. and P.A. Vander Werff. 2001. Mutualistic functioning of indigenous arbuscular mycorrhizae in spring barley and winter wheat after cessation of long - phosphate fertilization. Mycorrhiza 10 (4) : 195-201.

20. Diby, P. and Y. R. Samra .2006. Plant growth promoting Rhizobacteria mediated root profile ration in black pepper.

21. Dubey,KritiKumari. and M.H Fulekar 2011.Mycorrhizosp here development and management :the role of nutrients ,mico-

organisms and bio chemical activities ,Environmental Bi technology Laborator, Department of Life Sciences.University Mumbai.Santacruz(E) Mumbai- 400098.India of Agric.Biol. .J.N.Am.2(2):315-32.

22. Evelin, H.R. Kapoor and B.Giri. 2009. Arbuscular Mycorrhizal Fungi in All-Eviation of Salt Stress : Areview . Annals of Botany pp: 1 – 18.

23. Jackson, M. L. 1958. Soil Chemical Analysis Prentice ,Inc.Englewood Cliffs,N.J. pp:125-134

24. Jensen,A. and L. Jakobsen, 1980.The occurrence of VA mycorrhiza in barley and wheat grown in fertilizer treatments. Plant and Soil. 55:403-414

25. John, M. K. 1970. Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. Soil. Sci. 109 : 214-200

26. Hamdan, N. T. 2011. Effect of Fungus *Gloms mosseae* , Bacteria *Azotobacter chrooccocum* and Chemical Fertilizer Level in Increasing some Growth and Production in corn (*Zea mays* L.) M.Sc.Thesis. University of Mustansirya.

27. Hameeda, B.; G. Harrini ; O.P. Rupela ; S.P. Wani and G. Reed . 2008. Growth promotion of maize by phosphate solubilizing bacteria isolated from composts and micro fauna. Microbiol. Res. 163 : 234-242

28. Havlin, J.L.; J. D. Beaton ; S .L. Tisdale and W.L. Nelson . 2005. Soil Fertility and Fertilizers" An Introduction to Nutrient Management"7th ed. Prentice Hall . New Jersey.pp:515

29. Khan, M. S.; A. Zaidi and P.A. Wani. 2007. Role of phosphate solubilizing micoorganisms insustainable agriculture. a review. Agr- on . Sustain Develop. 27: 29-43.

30. Klopper ,J. W. R. Lifshitz. and R. M. Zablotowicz .1989. Free-living bacterial inocula for enhancing crop productivity . Trends in Biotechnology .7:39-44

31. Mahmood,I and R.Rizvi. 2010. Mycorrhiza and organic farming. Asian Journal of Plant Sciences,9(5):241-248.

32. Mardad, I M; A. Serrano and A. Soukri. 2013. Solubilization of inorganic phosphate and production of organic acids by bacteria isolated from a Moroccan mineral phosphate deposit. African Journal of Microbiology Research. 7(8), : 626-635

33. Marschner, P.; Crowley, D. and Z. Rengel . 2010. Interactions between rhizosphere microorganisms and plants governing iron and phosphours availability . World Congress of Soil Science , Soil Solutions for Changing World. 1-6 August, Brisbane, Australia

34. Mengel, K. and E. A. Kirkby. 1982. Principles of Plant Nutrition. International Potash Institute Bern. Switzerland.pp:200-250

35. Nirmalnath, P.Jones. 2010. Mole- cular diversity of Arbusculer Mycorrhizal Fungi, pink- Pigmented Facultative Methylotrophic Bacteria and Their influence On Grapevine (*vitis vinifera*). University of Agriculture Sciences. Dharwad. pp:122

36. Park, M.; D. Singvilay,; Y.Seok; J.Chung; K.Ahn. and T. Sa. 2003. Effect of phosphate solubilizing fungi on ‘P’ uptake and growth of tobacco in rock phosphate. Appl. Soil Korean J. Soil Sci. Fertil. 36: 233-238.

37. Polemio,M. and J. D. Rhoades, 1977. Determining cation exchange capacity. Anew proced.ure for calcareous and gypsiferous soils . Soil. Sci. Soc.Amer.J. 1941 : 524-528.

38. Rabie, G. H. 2005. Contribution of arbuscular mycorrhizal fungus to red kidney and wheat plants tolerance grown in heavy metal-polluted soil. African Journal of Biotechnology . 4(4) : 332-345

39. Richards,L.A. 1954. Diagnosis and improvement of saline and alkali soils. United. States, Department of Agriculture , Washington,D.C. Handbook No. 60 : 4-18

40. Roy – Bolduc, A. and M. Hijri. 2011. The use of Mycorrhizae to enhance phosphorus uptake: A way out the phosphorus crisis. J. Biofertil. Biopestici., 2 (104) :1 – 5 .

41. Safir,G.R., J.S. Boyer. and J.W.Gerdemann. 1972. Mycorrhizal enhancement of water transportion soybean. Sci. 172 : 581-583

42. Sanchez, C. A. 2007. Phosphorus. In-149 Barker, A. V. and Pilbeam D.J. (Eds) Handbook of Plant Nutrition. Taylor and Francis Group, LLC.Science. 11(1): 57-65

43. Shukla, V.; K. Srinivas and B. S. Prabhakar 1987. Response of bell pepper to nitrogen phosphorus and potassium fertilization. Indian. J Hortic. 44: 81-84.

44. Siddiqui, Z. 2006. PGPR: Prospective Biocontrol Agents of Plant Pathogens. In: Siddiqui, Z. (ed. PGPR: Biocontrol and Biofertilization Springer Netherlands, pp. 111-142. Available from: http://dx.doi.org/10.1007/1-4020-4152-7_4

45. Sindhu, S.S.; S. Dua; M.K. Verma, and A.Khandelwal. 2010. Growth Promotion of Legumes by Inoculation of Rhizosphere Bacteria. In: Microbes for Legume Improvement. (Eds. Khan, M.S., Zaidi, A. and Musarrat, J.). Springer-Wien/New York, Germany. pp. 195-235

46. Slafer, G.A. 2007. Physiology of Determination of Major Wheat Yield Components In : Buck , H.T., J.E. Nisi , and N. Salomon , Wheat Production in Stressed Environments Proceedings of the 7th international Wheat onference, 27 November -2 December 2005, Mardel plata , Argentina. Springer .pp: 794.

47. Subramanian, K.S. and C. Charest. 1999. Acquisition of N by external hyphae of an *Arbuscular Mycorrhizal* fungus and its impact on physiological responses in maize under drought – stressed and well – watered conditions Mycorrhiza 9 : 69-75.

48. Swedrzynska , D. 2000 . Effect of inoculation with *Azospirillum brasilense* on development and yielding of winter wheat and oat under different cultivation conditions. J. Env.Stu.Vol.9, No.5: 423 – 428

49. Tahat, M.M.; S. Kamaruzaman and R. Othman . 2010. Mycorrhizal fungi as A Biocontrol Agent. Plant pathology Journal, 9 (4): 198-207

50. Tahir, M. and M. A. Sarwar . 2013 . A Budding complement of synthetic fertilizers for improving crop production. Pak. J. Life Soc. Sci. 11 (1) : 1-7.

51. Tauson, E.L. and S. Vinogrado, 1988. Extracellular enzymes of *Bacillus mucilaginosus.* Mikrobiologiya 57: 236-240.

52. Tisdale,S.L.; W.L. Nelson and J.D. Beaton. 1986. Soil fertility and Ferilizers. Macmillan Publishing Company. New York. Collier Macmillan publishers London .pp:40-60

53. Turan, M.; N. Ataoglu and F.Sahin 2007. Effects of Bacillus S-3 on growth of tomoato (*Lycopersicon esculentum* Mill) plants and availability of phosphorus in soil. Plant Soil Environ .53(2):58-64.

54. USDA, Salinity Laboratory Staff. 1954. Diagnosis and Important of Saline and alkalin Soils . Hand book No. 60. Washington, D. C., U.S.A

55. Utobo, E.B.; E.N. Ogbodo.and A.C. Nwogbaga. 2011. Techniques for ex-traction and quantification of arbuscular mycorrhizal fungi Libyan agriculture research center journal internation . 2(2):68-78

56. Wiedenhoeft,A.C. 2006. Plant nutrient. University of Western Ontario. pp:144.

57. Woyessa, D. and Assefa, F. 2011. Effect of plant growth promoting rhizobacteria on growth and yield of Tef (Eragrostis tef Zucc . Trotter) under greenhouse condition. Res . J. Microbia., l6 : 343 – 355.

58. Wu, Z.; L.Guo; S.Qin and C. Li .2012. Encapsulation of R. planticola Rs-2 from-starch-bentonite and its controlled release and swelling behavior under simulated soil conditions. J. Ind. Microbiol. Biotechnol. 39: 317-27

59. Yazdani, M.; M. K. Bahmanyar; H. Pirdashti and M.A. Esmaile. 2009. Effect of phosphate solubilization microorganism (PSM) and plant growth promotion rhizobacteria (PGPR) on yield componenets of corn (*Zea mays* L.) : World Academy of Science,Engineering and Technology . 37 : 9

60. Zhang, C.J.; G.Q. Tu and C.J. Cheng.2004. Study on potassium dissolving ability of silicate bacteria. Shaguan College J. 26: 1209-1216.